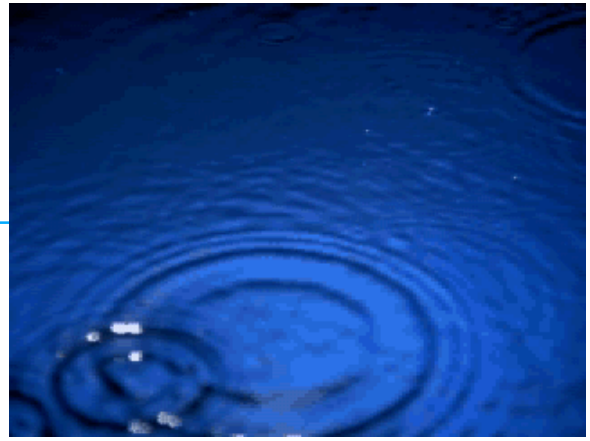
GPM

GLOBAL PRECIPITATION MEASUREMENT

Update on the Global Precipitation Measurement (GPM) Mission



October 18, 2005

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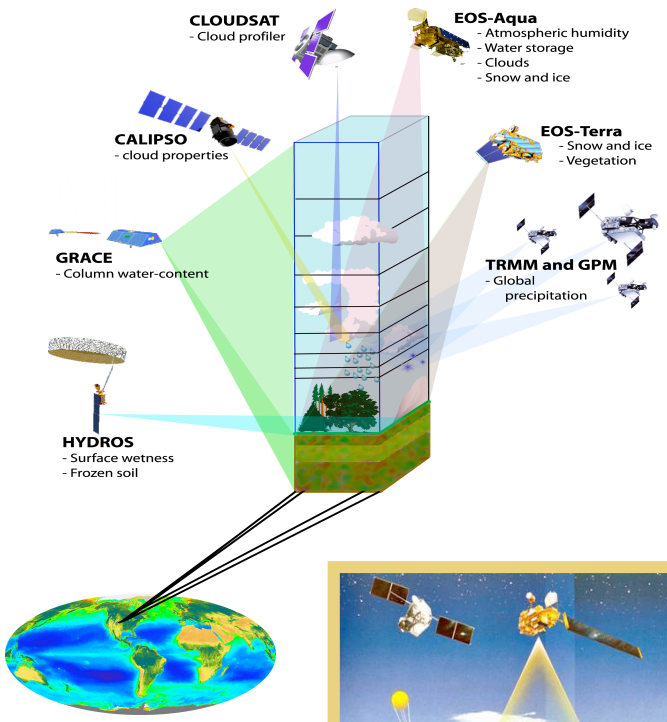
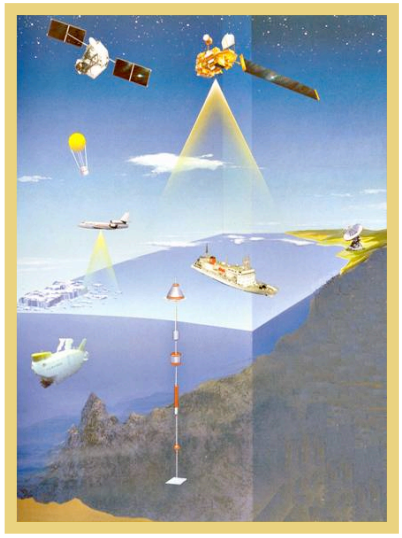
National Academies Committee Meeting on the Future of Rainfall Measuring Missions, Washington, DC

Outline

- *GPM science objectives and observation context*
- *Evolution from TRMM to GPM*
- *GPM capabilities*
- *GPM validation*
- *GPM applications*
- *NASA-NOAA partnership opportunities*

Global Water and Energy Cycle Observation Strategy





GPM

- ***Flagship mission for NASA's Global Water and Energy Cycle (GWEC) research and applications***
- ***Important contribution to the U.S. Climate Change Science Program & the U.S. Weather Research Program***
- ***Building on***
  - ***the success of TRMM***
  - ***NASA/JAXA capabilities in precipitation measurements from space***
  - ***national and international partnerships in satellite constellation formation and ground validation***
- ***Prototype for the emerging Global Earth Observing System of Systems (GEOSS), an international effort to provide comprehensive, long-term, and coordinated observations of the Earth***

GPM Science Objectives

- ***Advancing precipitation measurement capability from space:***
  - *through combined use of active and wide-band passive remote-sensing techniques*
- ***Advancing understanding of global water/energy cycle variability and fresh water availability:***
  - *through better measurement of the space-time variability of global precipitation*
- ***Improving weather forecasting skills:***
  - *through more accurate and frequent measurement of instantaneous rain rates*
- ***Improving climate modeling & prediction capabilities:***
  - *through better understanding of precipitation microphysics, surface water fluxes, soil moisture storage, and atmospheric latent heating distribution*
- ***Improving prediction capabilities for floods, droughts, fresh water resources, crop conditions, & other water-related applications:***
  - *through improved temporal sampling and high-resolution spatial coverage*

A science mission with integrated applications goals

Evolution from TRMM to GPM

Typical 3-hour Coverage Map

TRMM has demonstrated the advantages of using a precipitation radar together with a passive microwave radiometer to provide scientifically robust rainfall measurements from space.

GPM core satellite carries

- a dual-frequency radar (DPR)
- a passive microwave imager (GMI) with high-frequency capabilities

to serves as

- a precipitation physics observatory
- a calibration/training system

to refine *global* precipitation measurements from a constellation of dedicated and operational PMW radiometers.

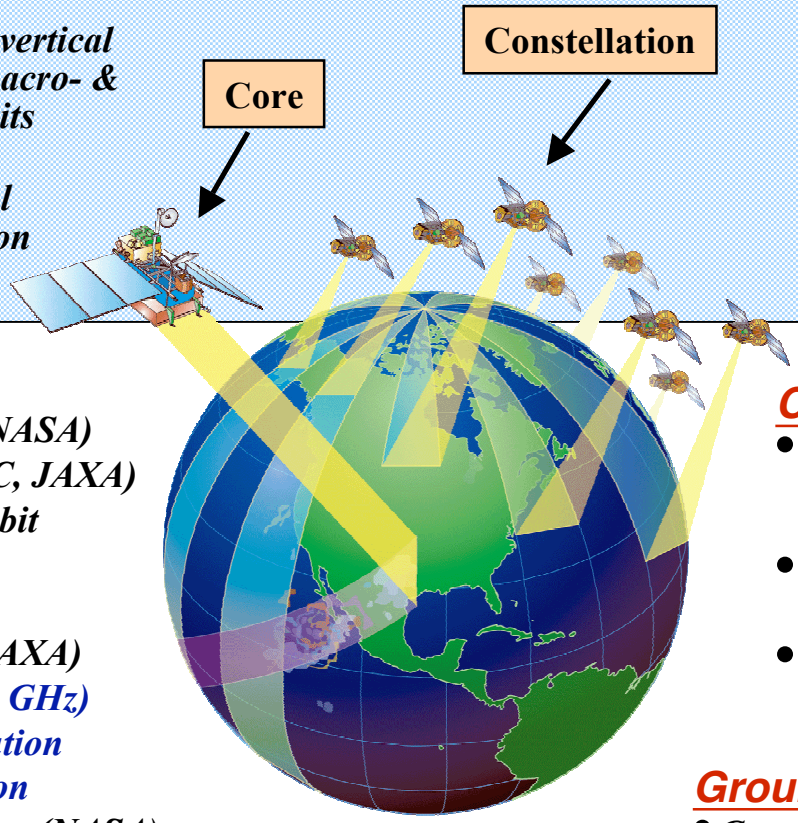
GPM Reference Concept

OBJECTIVES

- *Understand horizontal & vertical structure of rainfall, its macro- & micro-physical nature, & its associated latent heating*
- *Train & calibrate retrieval algorithms for constellation radiometers*

OBJECTIVES

- *Provide sufficient global sampling to significantly reduce uncertainties in short-term rainfall accumulations*
- *Extend scientific and societal applications*



Core Satellite

- *TRMM-like spacecraft (NASA)*
- *H2-A rocket launch (TBC, JAXA)*
- *Non-sun-synchronous orbit*
  - *~ 65° inclination*
  - *~407 km altitude*
- *Dual frequency radar (JAXA)*
  - *Ku-Ka Bands (13.6-35.5 GHz)*
  - *~ 4 km horizontal resolution*
  - *~250 m vertical resolution*
- *Multifrequency radiometer (NASA)*
  - *10.65, 18.7, 23.8, 36.5, 89.0, 166, 183.3 GHz*

Constellation Satellites

- *Pre-existing operational-experimental & dedicated satellites with PMW radiometers*
- *Revisit time*
  - *3-hour goal at ~90% of time*
- *Sun-synch & non-sun- synch orbits*
  - *600-900 km altitudes*

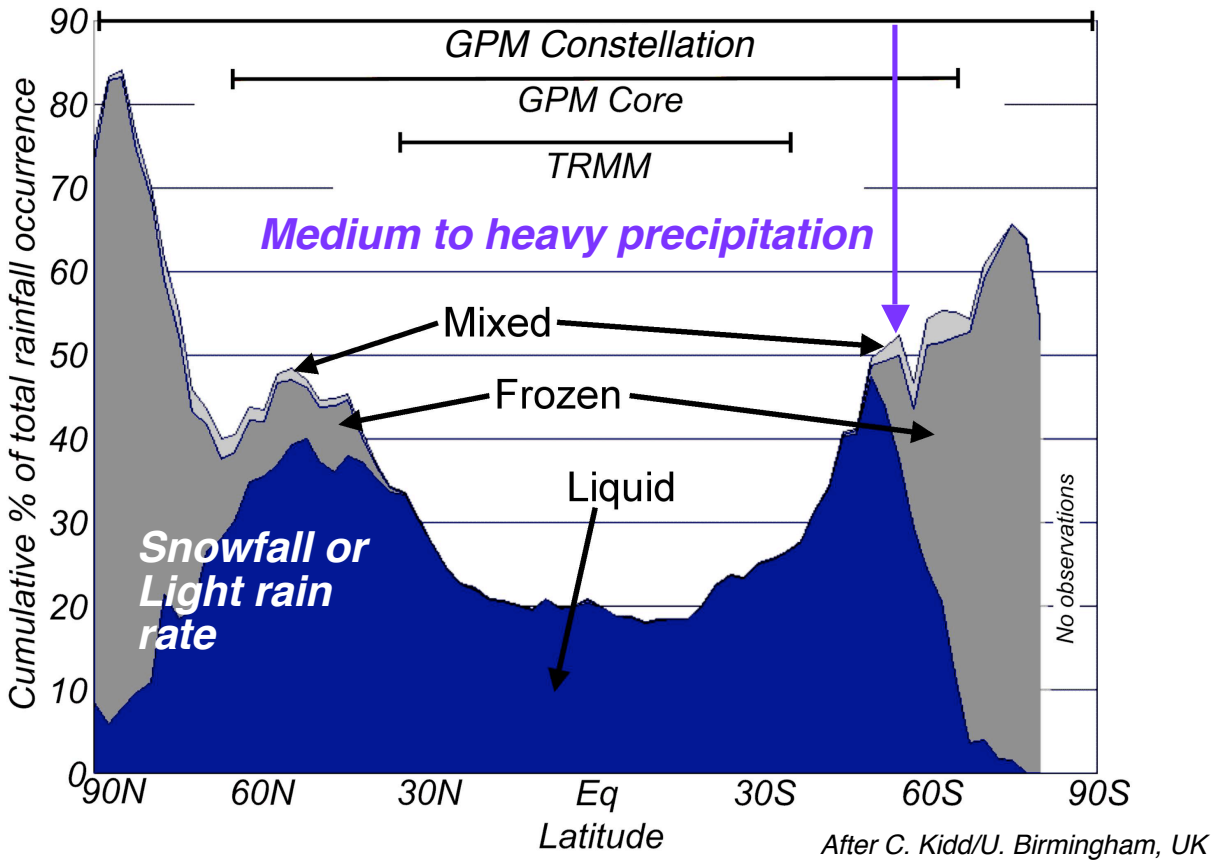
Ground Validation Sites

- *Ground measurement & calibration*
- *Cooperative international partners*

Precipitation Processing System

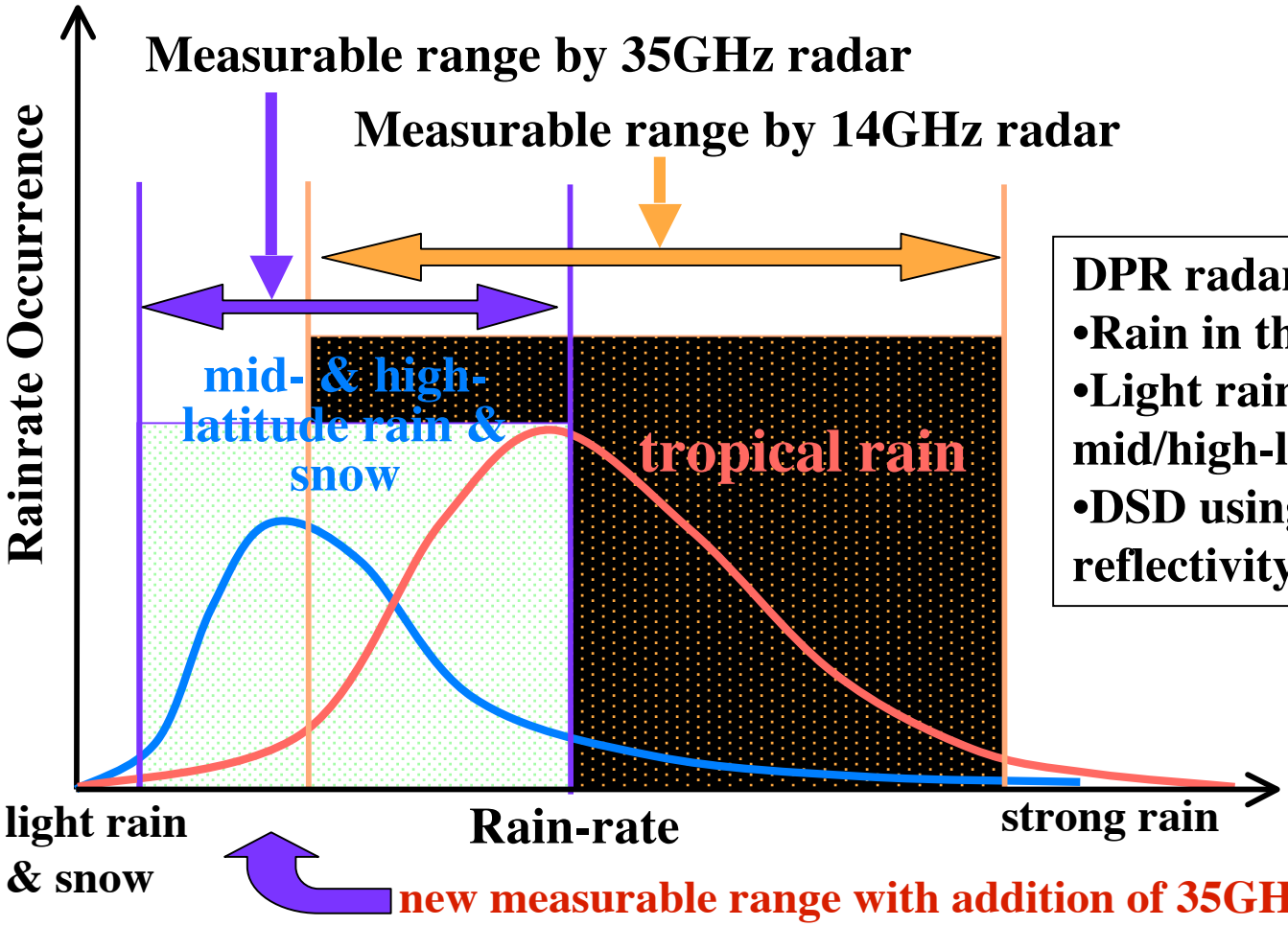
- *Global precipitation products from input data provided by a consortium of cooperative international partners*

Precipitation regimes



Detection of light rain (< 0.5 mm/h) and snow requires HF (> 90 GHz) radiometer channels and greater radar sensitivity than TRMM/PR

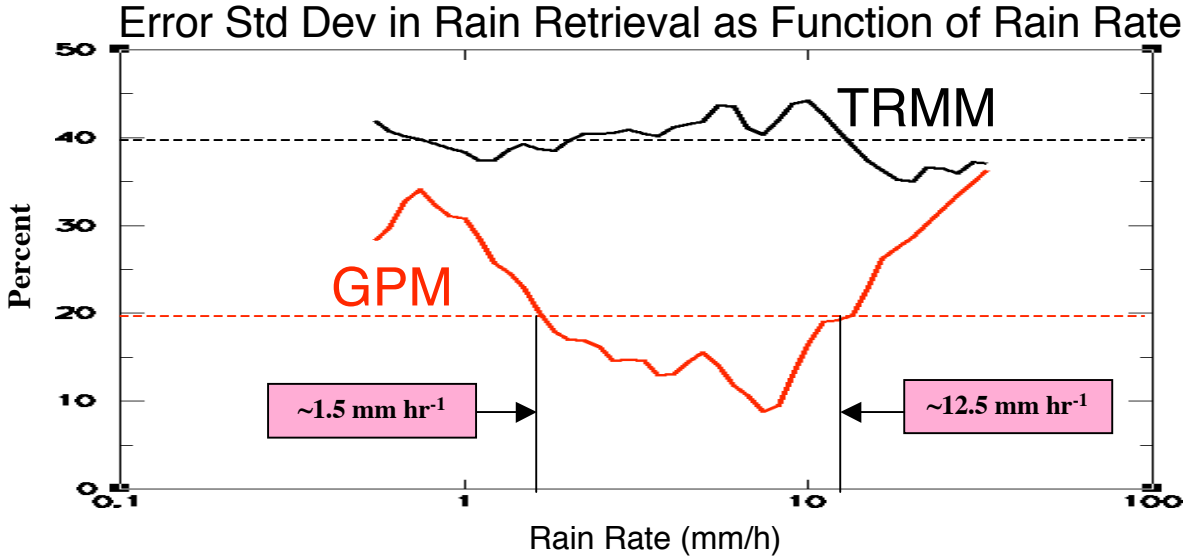
JAXA/NICT Dual Frequency (13.6, 35.55 GHz)
Ku-Ka Band Precipitation Radar (DPR)



DPR radar will measure:
- **Rain in the tropics**
- **Light rain & snow in mid/high-latitudes**
- **DSD using differential reflectivity**

Advantages of GPM DPR over TRMM PR

- ***Increased sensitivity for light rain and snow detection*** – *Addition of Ka band (35.5 GHz) to Ku band (13.6 GHz) improves the detection threshold from 0.5 to 0.17 mm/h, significantly improving measurements of rain occurrences in light rain and snow events*
- ***Better overall measurement accuracy*** - *replacing the surface reference technique for path-integrated-attenuation correction with dual-frequency methods*
- ***More detailed microphysical information*** – *detection of drop size distribution and identification of liquid, frozen, and mixed phase precipitation to provide an improved cloud database for rain & snow retrievals for both the Core and constellation radiometers*

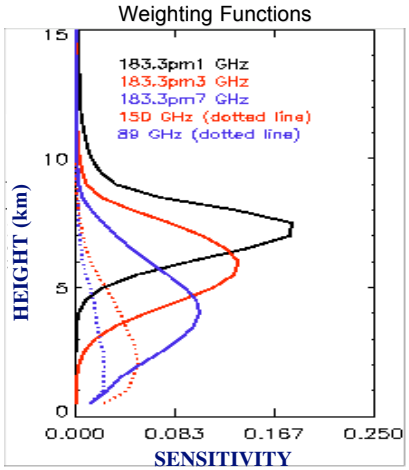


Simulated retrievals based on synthetic noises added to Hurricane Bonnie observations and an assumed drop size distribution

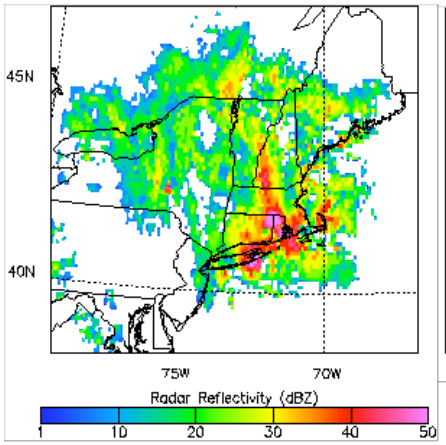
Z. Haddad et al. (JPL)

Science value of HF channels on GMI

- ***Measurement of frozen precipitation***
- ***Measurement of light rain***
- ***Improved PMW retrieval algorithms over land***
- ***Improved precipitation measurements in mid- and high-latitudes in cold seasons***
- ***HF channels on GPM Core enabling the testing and evaluation of constellation PMW algorithms using the DPR***

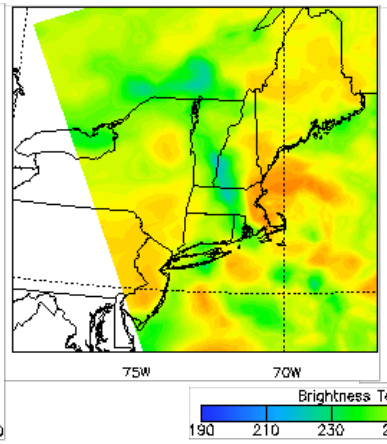


NOAA NEXRAD Data



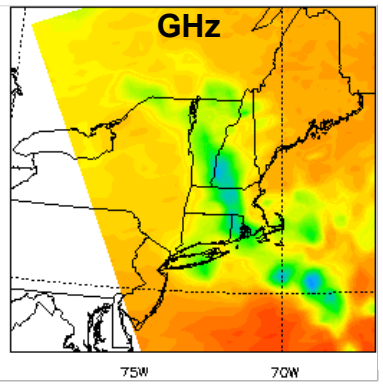
Radar reflectivity composite of the March 5-6, 2001 New England blizzard (75 cm of snow fell on Burlington, VT)

AMSU-B 89 GHz



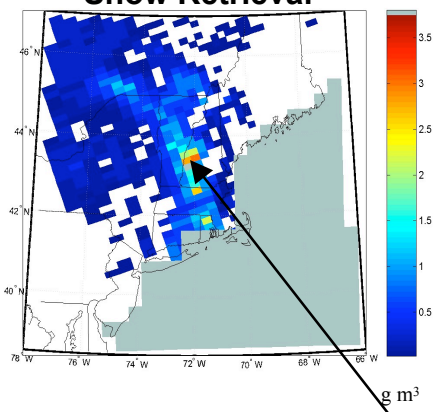
Surface effects evident over the Great Lakes, the St. Lawrence River, and along the Atlantic coast. Cannot distinguish surface from cloud effects.

AMSU-B 183.3 ± 7 GHz



Surface effects screened by water vapor. Snowfall appears over New England as low brightness temperatures

Snow Retrieval



Feasibility demonstration of snowfall retrieval using HF channels 4 in/h

G. Skofronick-Jackson et al. (GSFC)

GPM sampling and coverage

Current average revisit time by PMW radiometers

TRMM, Aqua, F13, F14, F15

(< 3h over 34% of globe)

hour

Expected GPM-era average revisit time

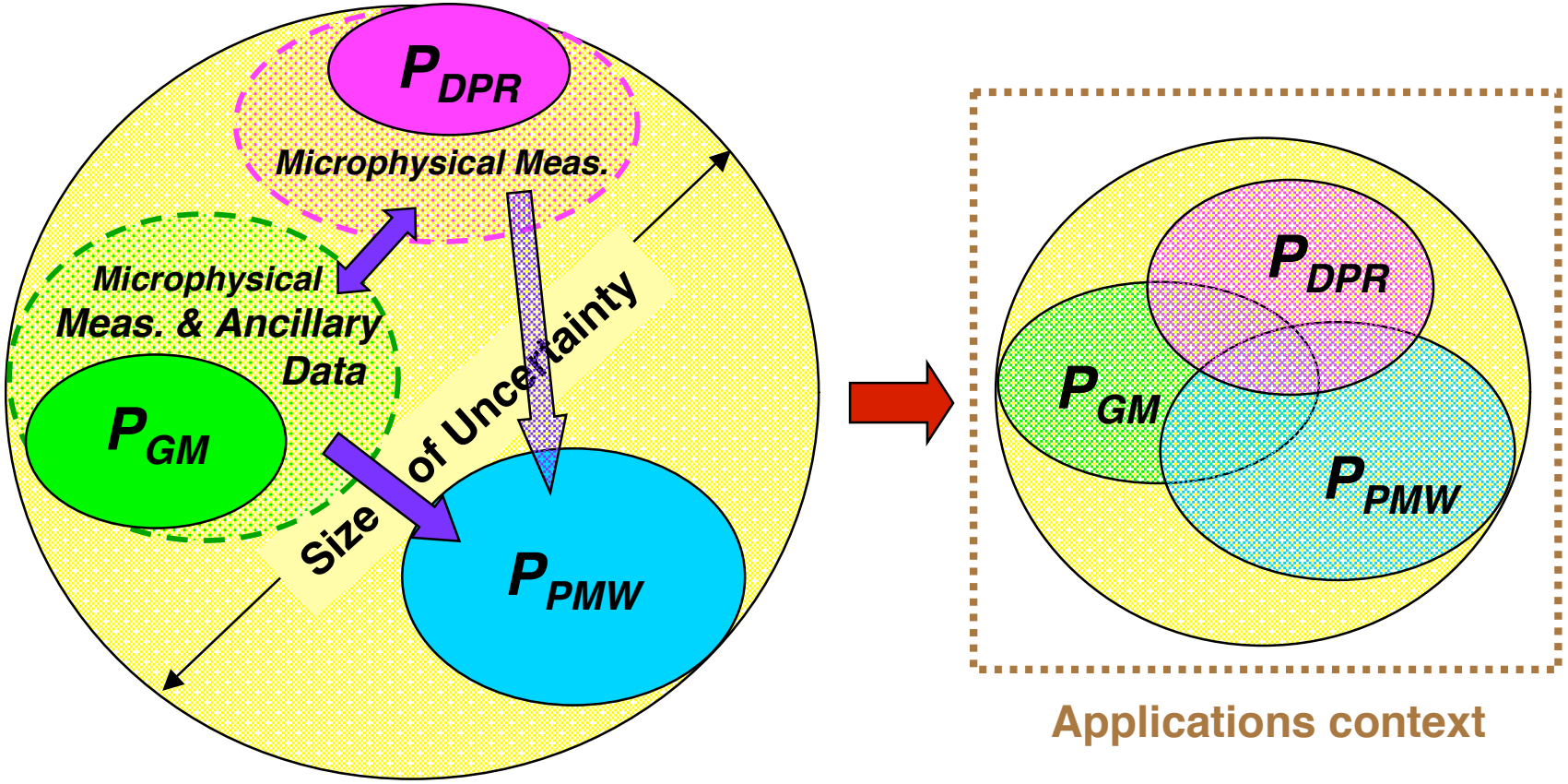
GPM Core, GCOM-W, NASA-1, EGPM, 3 NPOESS's

(< 3h over 96% of globe)

hour

GPM Validation Concept

GPM validation goes beyond direct comparisons of surface precipitation rates between ground and satellite measurements



GV goal is to provide ground observations for direct satellite product assessment and for algorithm/application improvements

- ***Surface precipitation statistical validation sites for direct assessment of GPM satellite data products:***
  - *Co-located with existing or upgraded national network (NEXRAD etc.) and dense gauge networks to identify and resolve significant discrepancies between the national network and satellite estimates*
- ***Precipitation process sites for improving understanding and modeling of precipitation physics in physical and radiance spaces for satellite retrieval algorithm improvements:***
  - *Continental tropical, mid- and high-latitude sites (including orographic/coastal sites and targeted sites for resolving discrepancies between satellite algorithms)*
  - *Oceanic tropical and mid-latitude sites*
  - *Aircraft measurements*
- ***Integrated hydrological sites for improving hydrological applications:***
  - *Co-located with existing watersheds maintained by other US agencies and international research programs to use hydrological basins as an integrated measure of the goodness of precipitation products*

Sites of different categories can overlap.

NASA-NOAA partnership opportunities

GPM data products

1. *Level 1 Orbital Swath Brightness Temperatures From NASA Sensors (within 15 minutes of observation at 90% of time)*

2. *Level 2 Orbit Swath Products (similar to TRMM) and 3-Hourly Outreach Rain Maps (updated as data arrive)*

3. *Level 3 Grid Products*

   (1) 3-hourly @ 0.25 x 0.25 deg; (2) daily @ 0.25 x 0.25 deg;
   (3) pentad @ 0.25 x 0.25 deg; (4) monthly @ 0.25 x 0.25 deg

   - Simplified & integrated parameter set:
   (1) surface precipitation rate, (2) convective-stratiform separation, (3) latent heating profile, (4) bulk DSD parameters, (5) confidence index

   - Three types of retrieval products ordered by retrieval quality:
   (1) core (combined DPR - GMI) product, (2) constellation radiometer product, (3) microwave radiometer and sounder (e.g., AMSU, ATMS) product

4. *Full Resolution Pixel Tables*

   Instantaneous rain pixels from all satellite sources within individual 3-h 0.25 x 0.25 deg grid elements

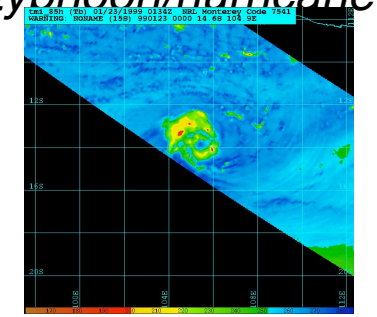
5. *Level 4 Merged Satellite Microwave-IR-Gauge Products*

Goal is a seamless transition of precipitation products from TRMM to GPM to maintain continuity in data records.

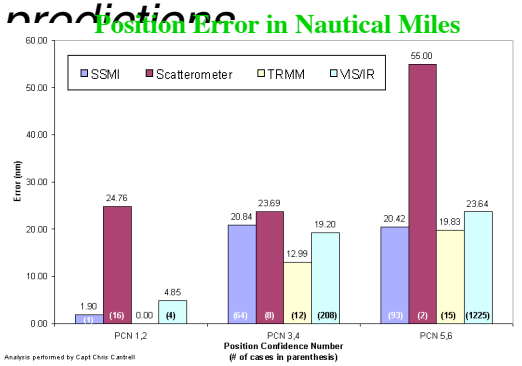
Lessons learned:

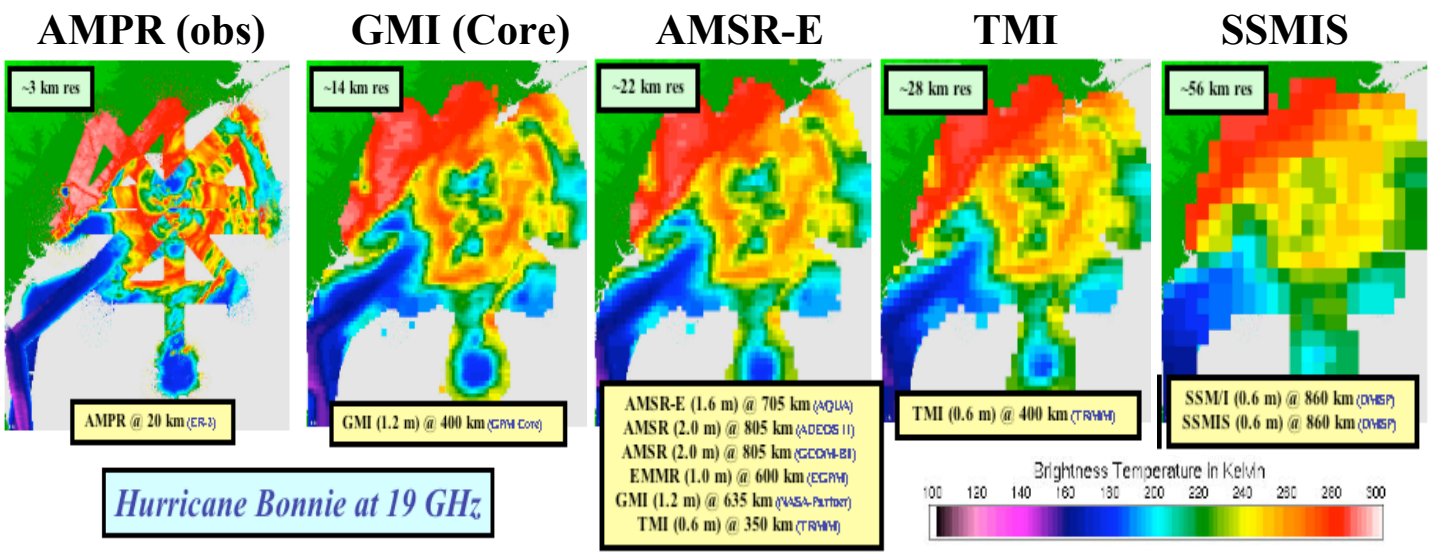
- ***Direct benefits of observations of precipitation intensity and structure***
  - *Monitoring extreme precipitation events and freshwater availability*
  - *Improving position fix for typhoon/hurricane predictions*

Higher-resolution GPM radiometer data can provide better position fixes in early stages of storm development



TMI 85GHz Image of enclosed eye with spiral bands





Hurricane Bonnie at 19 GHz

Synthesized Brightness Temperatures (R. Hood NASA/MSFC)

Effective usage of GPM data in applications - II

- ***Research in the pre-GPM phase is crucial for developing innovative techniques to maximize the benefits of precipitation observations in many application areas:***
  - *NWP, data assimilation, and reanlaysis:*
    - *Advanced assimilation methods to extract maximum information from precipitation data in the presence of forecast model errors*
    - *Improved understanding and modeling of precipitation error properties*
  - *Hydrological modeling & prediction:*
    - *Innovative hydrological modeling and prediction systems*
    - *Hydrometeorological testbeds for evaluating the quality of satellite precipitation products in hydrological applications*
    - *Improved techniques for merging high-resolution global precipitation products based on combined satellite and ground measurements*

Ongoing & future GPM interactions with NOAA

- ***Space Hardware***
- ***Integration of IPO NPOESS and DMSP Satellite Series into GPM Constellation Fleet***
- ***Weather, Climate, and Hydrological Prediction***
- ***Coordination with NOAA's NCEP (e.g. HPC, CPC), National Weather Service (NWS), NESDIS, and others to understand NOAA's Operational Requirements for Using Precipitation Data in Model Assimilation, Short-term Forecasts/Nowcasts, Climate Prediction, River/Hydrologic Prediction, and Tropical Prediction***
- ***Joint Center for Satellite Data Assimilation (Goddard/NCEP) activities on rainfall assimilation to enhance existing efforts to effectively assimilate existing and emerging satellite datasets into NOAA models***
- ***Ongoing Discussions with NOAA Hydrologic Divisions on integration of GPM data into blended gauge-radar products and software.***
- ***Science Coordination Activities***
- ***Significant NOAA Participation in ongoing GPM Science Workshop Series, Working Group Report Development, and Science Implementation Plan Development***
- ***Ad-Hoc NASA-NOAA GPM Working Group to identify and nurture GPM partners and identify funding lines in NOAA budget***
- ***NASA-NOAA Research and Operations (R&O) Working Group to define "Global Precipitation Measurement Capability"***